

## CLAIMS

What is claimed is:

1. A method of hydraulically fracturing a hydrocarbon-bearing subterranean formation which comprises:

5 pumping a first proppant stage either into a propagated fracture or into the formation at a pressure sufficient to fracture the formation; and

optionally, pumping a second proppant stage into the fracture wherein at least one of the following conditions prevail:

(i.) the first proppant stage and/or the optional second proppant stage contains  
10 a first proppant and a second proppant wherein at least one of the first or second proppant is a ULW proppant having a density less than or equal to 2.45 g/cc;

(ii.) the density differential between the first proppant stage and the second proppant stage is greater than or equal to 0.2 g/cc and either the first proppant stage and/or the second proppant stage contains a ULW proppant;

15 (iii.) both the first proppant stage and the second proppant stage contain ULW proppants;

(iv.) the proppant of the first proppant stage and/or the second proppant stage contains a ULW proppant and the rate of injection of the second proppant stage into the fracture is different from the rate of injection of the first proppant stage; or

20 (v.) the proppant of the first proppant stage and/or the second proppant stage contains a ULW proppant and the particle size of the second proppant stage is different from the particle size of the first proppant stage.

2. The method of Claim 1, wherein the first proppant stage and/or the  
25 optional second proppant stage contains a first proppant and a second proppant, wherein both the first proppant and second proppant are a ULW proppant.

3. The method of Claim 1, wherein the density differential between the first proppant stage and second proppant stage is greater than or equal to 0.2 g/cc.

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4. The method of Claim 3, wherein the first proppant stage is a pad fluid and contains a ULW proppant.

5. The method of Claim 4, wherein the effective propped length of the fracture after pumping of the first proppant stage is greater than the effective propped fracture length of a fracture pumped with a substantially similar pad fluid which does not contain a ULW proppant.

6. The method of Claim 4, wherein the second proppant stage contains a ULW proppant.

7. The method of Claim 2, wherein the density differential of the first proppant stage and the second proppant stage is greater than or equal to 0.2 g/cc.

8. The method of Claim 1, wherein the effective propped length of the fracture after pumping of the second proppant stage is greater than the effective propped length of the fracture prior to the injection of the second proppant stage.

9. The method of Claim 1, wherein the proppant of the first proppant stage and/or the second proppant stage contains a ULW proppant and the rate of injection of the second proppant stage is less than the rate of injection of the first proppant stage.

10. The method of Claim 1, wherein the proppant of the first proppant stage and/or the second proppant stage contains a ULW proppant and the particle size of the second proppant stage is greater than the proppant size of the first proppant stage.

11. The method of Claim 1, wherein a second proppant stage containing a ULW proppant is pumped into the fracture and further wherein the first proppant stage is sand, ceramic, sintered bauxite or a resin coated proppant.

12. The method of Claim 1, wherein the density of the ULW proppant is less than or equal to 2.25 g/cc.

13. The method of Claim 12, wherein the density of the ULW proppant is less  
5 than or equal to 2.0 g/cc.

14. The method of Claim 13, wherein the density of the ULW proppant is less than or equal to 1.75 g/cc.

10 15. The method of Claim 14, wherein the density of the ULW proppant is less than or equal to 1.25 g/cc.

16. A method of hydraulically fracturing a hydrocarbon-bearing subterranean formation which comprises introducing a first proppant stage into the formation at a  
15 pressure sufficient to propagate a fracture or into a propagated fracture, wherein the first proppant stage comprises a first proppant and a second proppant, wherein the first proppant and/or second proppant is a an ultra lightweight (ULW) proppant having a density less than or equal to 2.45 g/cc.

20 17. The method of Claim 16, wherein the density differential between the first proppant and the second proppant is about 0.2 g/cc.

18. The method of Claim 17, wherein the density of the ULW proppant is less than or equal to 1.75 g/cc.  
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19. The method of Claim 18, wherein the density of the ULW proppant is less than or equal to 1.25 g/cc

20. The method of Claim 16, further comprising injecting a second proppant  
30 stage into the subterranean formation, wherein at least one of the following conditions prevail:

(i.) the second proppant stage contains a first proppant and a second proppant wherein at least one of the first proppant and second proppant is a ULW proppant;

(ii.) the proppant of the second proppant stage is a ULW proppant and the density differential of the first proppant stage and the second proppant stage is greater  
5 than or equal to 0.2 g/cc;

(iii.) the rate of injection of the second proppant stage into the fracture is different from the rate of injection of the first proppant stage; or

(iv.) the particle size of the second proppant stage is different from the particle size of the first proppant stage.

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21. The method of Claim 20, wherein the proppant of the second proppant stage is a ULW proppant and the density differential between the first proppant stage and the second proppant stage is greater than or equal to 0.2 g/cc.

15 22. The method of Claim 20, wherein the proppant of the second proppant stage is a ULW proppant and the rate of injection of the second proppant stage is less than the rate of injection of the first proppant stage.

20 23. The method of Claim 20, wherein the proppant of the second proppant stage is a ULW proppant and the particle size of the second proppant stage is greater than the proppant size of the first proppant stage.

24. The method of Claim 20, wherein the density differential between the first proppant stage and the second proppant stage is greater than or equal to 0.2 g/cc and  
25 further wherein the second proppant stage contains a first proppant and a second proppant, the density differential of the first proppant and the second proppant of the second proppant stage being greater than or equal to 0.2 g/cc.

25. The method of Claim 20, wherein the density of the ULW proppant of the  
30 second proppant stage is less than or equal to 2.0 g/cc.

26. A method of hydraulically fracturing a hydrocarbon-bearing subterranean formation which comprises:

(a.) introducing into the formation at a pressure sufficient to propagate a fracture or into a propagated fracture a first proppant stage comprising a proppant having  
5 a density greater than 2.45 g/cc; and

(b.) introducing into the formation a second proppant stage, comprising an ultra lightweight (ULW) proppant having a density less than or equal to 2.45 g/cc.

27. The method of Claim 26, wherein the rate of injection of the second  
10 proppant stage into the fracture is different from the rate of injection of the first proppant stage.

28. The method of Claim 26, wherein the particle size of the second proppant stage is different from the particle size of the first proppant stage.  
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29. The method of Claim 26, wherein the second proppant stage contains a first proppant and a second proppant wherein the density differential of the first proppant and the second proppant is greater than or equal to 0.2 g/cc.

30. The method of Claim 26, wherein the density of the ULW proppant of the second proppant stage is less than or equal to 2.25 g/cc.  
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31. The method of Claim 30, wherein the density of the ULW proppant of the second proppant stage is less than or equal to 2.0 g/cc.  
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32. The method of Claim 26, wherein the first proppant stage is a pad fluid and is introduced into the formation at a pressure sufficient to initiate a fracture.

33. A method of fracturing a subterranean formation comprising:  
30 pumping a pad fluid containing a first proppant stage into the formation at a pressure sufficient to initiate a fracture;

injecting a second proppant stage into the fracture.

wherein the first proppant stage, and optionally the second proppant stage, is an ultra lightweight (ULW) proppant having a density less than or equal to 2.45 g/cc.

5           34.    The method of Claim 33, wherein the density differential between the proppant of the first proppant stage in the pad fluid and the proppant of the second proppant stage is at least 0.2 g/cc.

          35.    The method of Claim 34, wherein the second proppant stage has a density  
10   greater than 2.45 g/cc.

          36.    The method of Claim 35, wherein the second proppant stage is sand, ceramic, sintered bauxite or resin coated proppant.

15           37.    The method of Claim 33, wherein the second proppant stage contains a ULW proppant having a density less than or equal to 2.45 g/cc.

          38.    The method of Claim 37, wherein the density of the ULW proppant is less  
20   than or equal to 1.75 g/cc.

          39.    The method of Claim 38, wherein the density of the ULW proppant is less  
than or equal to 1.25 g/cc.

          40.    The method of Claim 33, wherein the effective propped length of the  
25   fracture after injection of the second proppant stage is greater than the effective propped  
length of the fracture prior to the injection of the second proppant stage.

          41.    The method of Claim 33, which further comprises introducing a third  
proppant stage into the fracture, wherein at least one of the following conditions prevail:

30           (a.)   the density differential of the proppant in the third proppant stage and the  
proppant of the second proppant stage is greater than or equal to 0.2 g/cc.

(b.) the rate of injection of the third proppant stage is less than the rate of injection of the second proppant stage; or

(c.) the particle size of the third proppant stage is different from the particle size of the second proppant stage.

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42. The method of Claim 41, wherein the effective propped length of the fracture after injection of the third proppant stage is greater than the effective propped length of the fracture prior to the introduction of the third proppant stage.

10 43. A method of hydraulically fracturing a hydrocarbon-bearing subterranean formation which comprises:

introducing a first proppant stage either into the formation at a pressure sufficient to propagate a fracture or into a propagated fracture; and

injecting a second proppant stage into the fracture

15 wherein the rate of injection of the second proppant stage into the fracture is different from the rate of injection of the first proppant stage and further wherein the first proppant stage and/or second proppant stage contains an ultra lightweight (ULW) having a density less than or equal to 2.45 g/cc.

20 44. A method of hydraulically fracturing a hydrocarbon-bearing subterranean formation which comprises introducing into a formation a first proppant stage and a second proppant stage, wherein the first proppant stage and second proppant stage contain an ultra lightweight (ULW) proppant having a density less than or equal to 2.45 g/cc.

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45. The method of Claim 44, wherein the density differential between the first proppant stage and the second proppant stage is greater than or equal to 0.2 g/cc.

46. The method of Claim 44, wherein the first proppant stage is a pad fluid.

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47. The method of Claim 44, wherein the first proppant stage is a banking fluid.

48. The method of Claim 44, wherein the rate of injection of the second proppant stage is different from the rate of injection of the first proppant stage.

49. The method of Claim 48, wherein the rate of injection of the second proppant stage is less than the rate of injection of the first proppant stage.

50. The method of Claim 44, wherein the particle size of the second proppant stage is different from the particle size of the first proppant stage.

51. The method of Claim 50, wherein the particle size of the second proppant stage is greater than the particle size of the first proppant stage.

52. The method of Claim 44, wherein the effective propped length of the fracture after injection of the second proppant stage is greater than the effective propped length of the fracture prior to the injection of the second proppant stage.

53. The method of Claim 44, wherein the density of the ULW proppant is less than or equal to 1.75 g/cc.

54. The method of Claim 53, wherein the density of the ULW proppant is less than or equal to 1.25 g/cc.

55. A method of fracturing a subterranean formation comprising:  
creating a fracture in the formation by injecting a banking fluid containing a first proppant stage into the formation at pressure sufficient to allow formation of a proppant bank;  
injecting a second proppant stage into the fracture



wherein the density differential between the proppant of the first proppant stage in the banking fluid and the proppant of the second proppant stage is at least 0.2 g/cc; and

5 further wherein the proppant of either the first proppant stage or the second proppant stage is an ultra lightweight (ULW) proppant having a density less than or equal to 2.45 g/cc.

10 56. The method of Claim 55, wherein the effective propped length of the fracture after injection of the second proppant stage is greater than the effective propped length of the fracture prior to the injection of the second proppant stage.

57. The method of Claim 55, which further comprises introducing a third proppant stage into the fracture, wherein at least one of the following conditions prevail:

(a.) the density differential of the proppant in the third proppant stage and the proppant of the second proppant stage is greater than or equal to 0.2 g/cc.

15 (b.) the rate of injection of the third proppant stage is less than the rate of injection of the second proppant stage; or

(c.) the particle size of the third proppant stage is different from the particle size of the second proppant stage.

20 58. The method of Claim 55, wherein the density of the ULW proppant is less than or equal to 1.75 g/cc.

59. The method of Claim 55, wherein the effective propped length of the fracture after injection of the third proppant stage is greater than the effective propped  
25 length of the fracture prior to the introduction of the third proppant stage.